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PUBLISHED BY AUVSI FOR THE UNMANNED SYSTEMS COMMUNITY

USGS Takes to the Skies with Unmanned Aircraft

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AUVSI ASSOCIATION FOR UNMANNED VEHICLE SYSTEMS INTERNATIONAL

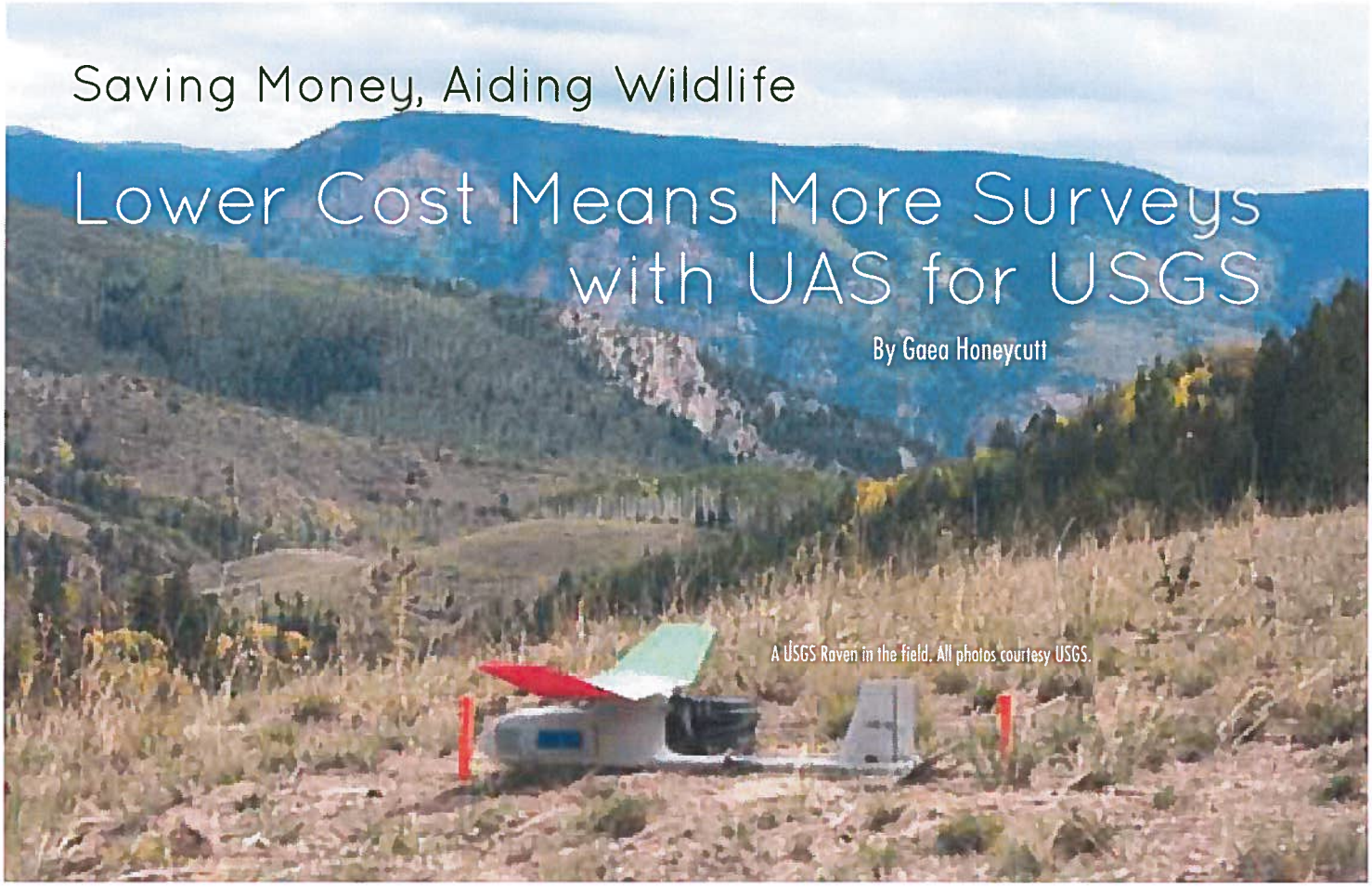
VOLUME 31 NO.1 • JANUARY 2013

2700 South Quincy Street, Suite 400, Arlington, VA 22206, USA

Saving Money, Aiding Wildlife

Lower Cost Means More Surveys with UAS for USGS

By Gaea Honeycutt



A USGS Raven in the field. All photos courtesy USGS.

Outside the military arena, unmanned systems applications are advancing quickly. However, civil applications are still limited to the government as the Federal Aviation Administration wrestles with the consequences — intended and untended — in opening civil skies to UAS. At the United States Geological Survey, unmanned aircraft are becoming indispensable tools for research and reporting.

After beginning missions in 2010, the USGS UAS Project Office has steadily increased activity. According to Mike Hutt, USGS UAS project manager, the agency created the UAS Project office with the express mission of providing UAS for a variety of Department of Interior missions. In 2010, they began working in the Office of Aviation Safety, which is responsible for maintaining the aircraft and providing operator training. Its parent agency, the Department of Interior, develops operational procedures for training officers and certifying operators.

USGS uses UAS for a number of projects, flying the Honeywell T-Hawk and the AeroVironment Inc. Raven for both specific USGS missions and for other bureaus and agencies within DOI. The T-Hawk features vertical takeoff and landing, as well as hovering and flight modes. The system comes with two T-Hawk vehicles and a ground station. It flies brief missions of just under an hour with the capability to store 10 flight plans with 100 waypoints per plan. Given the 3 to 6 mile communications range and ability to operate in disparate weather conditions, the T-Hawk is well suited to USGS missions.

The Raven, a lightweight UAS designed for rapid deployment and high mobility, is likewise suited to USGS missions. Operators can hand-launch the vehicle, which can gather low-altitude data in harsh conditions. With a 4.5-foot wingspan, the Raven has a range of 6.2 miles and flies between 60 and 90 minutes.

These systems are made more useful due to the payload options — particularly the advancement in sensor design. Hutt points to a lidar system that can be loaded on small UAS, "So, the traditional remote sensing that we use are all getting very, very small and very, very cheap."

Jeff Sloan, UAS operator, describes the difference size can make. "You can be more mobile at lower altitudes." He continues on the topic of new, lighter-weight cameras and how they allow the USGS to get closer, "Because they're so small, we can fly them in a tight canyon. Software-wise, we're able to take these cameras and make them usable in a mapping room."

USGS deploys different groups on to use the Raven and T-Hawk to detect chemicals, monitor plumes of gases during wildfires and keep an eye on volcanoes, among other projects. The makeup of wildfires has become a bigger issue as household chemicals are now a part of the burning materials in a forest, not just trees or shrubs.

"I guess the UAS tech feels kind of like when GPS was first introduced. We knew there was potential and used it for mapping, but now it's part of everyday life. If you want to go out

USGS hand-launches a Raven from a boat for a Missouri river bank erosion study.

and get a report of smoke in the area, you'll be able to launch from a park services building," Hutt explains.

The UAS Project Office looks forward to one upcoming project that wasn't previously practical. Scientists monitor benchmark glaciers, primarily in the Pacific Northwest, collecting satellite images.

"They've always had difficulty collecting data other than surface measurements. But they didn't have the capability of collecting information at various altitudes above the glaciers," explains Hutt. This new project under development will allow geologists to measure the impact of the air directly above the glaciers.

"Really that's the future of remote sensing," Hutt says. "I believe that by 2020, UAS will be the primary platform for remote sensing, and it will only take that long due to getting access to air space."

Rising Demand

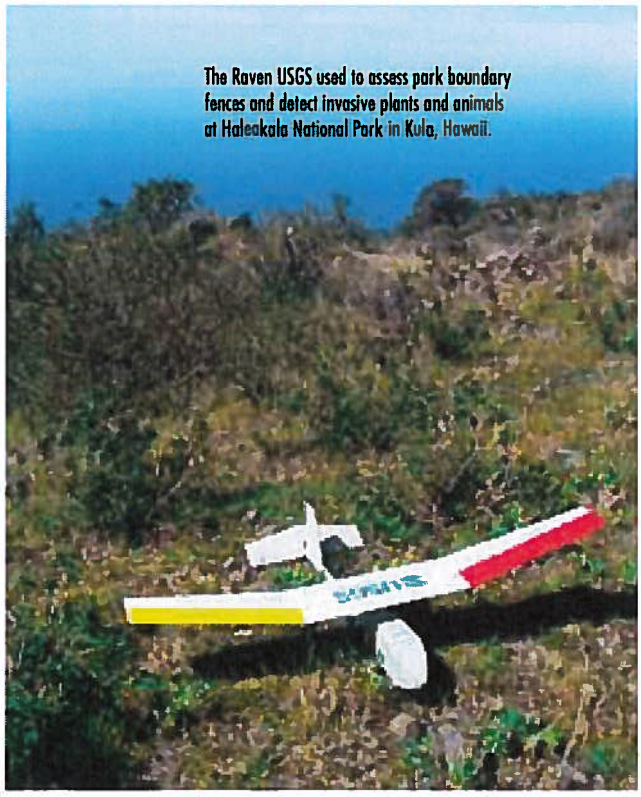
With USGS flying largely in restricted airspace, Hutt estimates the agency has undertaken about a dozen missions in the past 18 months, with demand rising. The increased interest in using UAS throughout the agency has grown organically as more staff become aware of the capabilities and potential.

"Within the department, the UAS applications are bubbling up from the ground level. Everyone is really pretty excited about the technology," says Hutt.

It's not uncommon for scientists to develop new projects while one is underway. Hutt described one mission with the Office of Surface Mining, Reclamation and Enforcement. "[We were supporting them] with some mining reclamation. While we were there they asked if we could also fly over and detect air pollution." However, sometimes there's a flood of ideas. "We have to ask them to hold on while we finish the current mission."

The excitement extends to offices other than those involved in geologic research and monitoring.

"The thing that really surprised me is that the wildlife biologists are very excited," he continues. "If you tagged an animal, there are a couple of kind of technologies that can track GPS or radio. Usually, they use helicopters or bigger aircraft. We've demonstrated that we can use the Raven, plot it out and track the herds."



The Raven USGS used to assess park boundary fences and detect invasive plants and animals at Haleakala National Park in Kula, Hawaii.

Much of this excitement is due to the cost savings. Conventional methods of monitoring and data collection are 10 times, or more, as expensive as using UAS.

"We have demonstrated that the small UAS we use [under 20-pound systems] are cost effective for a lot of our applications — site surveys, inventorying wildlife, etc." Hutt says.

They've been able to fly missions for $3,000-$5,000, versus $30,000 or more via conventional methods.

Another example is wildlife biology, which may require using helicopters or manned aircraft for anything from $30,000 to $50,000. Cost savings don't just come from the vehicles, but also some of the payloads. For example, the GoPro camera, a small, rugged device that has become a favorite of people who film high-risk sports or otherwise like to put cameras in harm's way.

"It's costing hundreds of dollars, where before we had to rely on mapping cameras [for] hundreds of thousands of dollars," says Hutt. All of which can make a difference in a tough economic environment, where agencies may experience deeper cuts this winter. He anticipates revisiting old ideas and past projects that were previously abandoned due to expense and availability of resources. There may be opportunities for ground monitoring where previously there were significant challenges.

Posting and Sharing

Another benefit is the ability to communicate. The video quality is good enough to post and share on the Internet.

"You can share that data in real time," says Sloan. "It's really expanding the community that has access to the information in real time. You don't have to get all the people together in one room anymore."

Those watching the live stream in another part of the country can monitor and discuss the mission and make decisions or provide feedback using chat applications.

This past November, the FAA decided to delay the selection of six UAS test sites, which had been scheduled for announcement in December. Citing privacy concerns, the agency will continue to deliberate on the impacts to the general public. As the FAA struggles with civil air rules, requests continue to be limited to public entities, but Hutt and Sloan see tremendous commercial potential. "We'll be contracting more for the services," Hutt predicts.

"With the integration of GPS into lower systems, private companies will be able to man the offices with much lower numbers of people," adds Sloan.

In fact, the new challenging reality at the UAS Project Office may not be the struggle to gather data, but the task of sorting and analyzing data.

"The analysis software is really not where we'd like," says Sloan. "We're still doing a lot manually."

Gaea Honeycutt is president of G.L. Honeycutt Consulting LLC and a freelance writer.

To listen to the NPR interview that includes Mike Hutt, scan this barcode with your smartphone.

USGS workers use small unmanned aircraft to study abandoned minelands in Colorado. All photos courtesy USGS.

Q&A: USGS National UAS Project Office

Editor's note: The following is a question and answer session with Michael E. Hutt of the U.S. Geological Survey's UAS Project Office. The USGS is the United States' largest water, earth, and biological science and civilian mapping agency and collects, monitors, analyzes and provides scientific understanding about natural resource conditions, issues and problems, including studying climate and land-use change and seeking to minimize the loss of life and property from natural disasters. In recent years, that mission has included the use of unmanned systems. For more on work the USGS has done with unmanned systems, see the June 2011 and September 2011 issues of Unmanned Systems *magazine.*

Q. When did USGS begin using unmanned aerial systems in your research?

A. The USGS' use of UAS technology goes back to 2004 when a UAS was used to acquire data during a volcanic event on Mount Saint Helens. After carefully monitoring the rapid advancements in the technology, USGS determined that UAS had reached a maturity stage and was ready to be employed for scientific, environmental and land management applications. The USGS UAS Project Office was created in May of 2008 to enable cost-effective and safe UAS technology into the Department of the Interior's decision-making toolbox. Since then we have worked across the Department of the Interior agencies, the Department's Office of Aviation Services, Department of Defense, Federal Aviation Administration and others to acquire systems, initiate operator training programs, certify the airworthiness of platforms and conduct missions. Much like the use of Internet technology, Geographic Information Systems (GIS) and GPS, unmanned aircraft systems have the potential of enabling us to be better stewards of the land.

Q. One of USGS' upcoming projects is inspecting and monitoring wildlife on Palmyra atoll in the Pacific. Can you tell us more about this project and how UAS are helping with your research?

A. Palmyra is one of the last uninhabited islands, or atolls, in the Pacific Ocean. USGS scientists work closely with the U.S. Fish and Wildlife Service, The Nature Conservancy and fellow Palmyra Atoll Research Consortium scientists to monitor and gain a better understanding of the key biophysical properties associated with ecosystem process, climate change and hydrology of the atoll. Because of the extreme remoteness of the island, it has been very difficult to acquire aerial imagery, and satellite systems are not of a sufficient resolution to support many of the scientific investigations. The UAS equipped with digital, high-definition thermal and color cameras will fly over the lagoon or hover in a position for studying water flow, nesting bird colonies, sea turtles and coral reefs. The UAS will provide a cost-effective opportunity to research and further develop techniques to measure biophysical and ecosystem properties. The UAS mission will provide a unique opportunity to correlate the ground measurements to the remote sensing data to improve the hydrologic, thermal and landscape assessments of aquatic wildlife, atoll vegetation, hydrologic changes, and bird habitat and behavior.

Q. From the Pacific to the Mojave Desert to West Virginia to Hawaii, USGS seems to be using UAS in a wide array of places. What makes UAS so adaptable to different locations?

A. The Department of the Interior manages more than 500 million acres, or about one-fifth of the United States. The management responsibilities are complex and require intricate, timely information. UAS technology is being evaluated by scientists, resource managers and emergency management staff for a wide range of applications. UAS provide the USGS, and our partners, with a cost-effective capability to gain access to an increased level of persistent monitoring of Earth surface processes in remote areas that have been difficult or nearly impossible to access before. The small size of a SUAS (under 20 pounds) makes it very easy to transport them across the

country using overnight mail delivery systems. The most exciting development is the miniaturization and variety of readily available sensor packages. Using a SUAS, we are able to tailor solutions to meet project requirements. We can obtain very high-resolution video, acquire thermal imagery, detect chemical plumes, collect point cloud data and locate animals that have been tagged with tracking devices at a fraction of the cost of conventional surveying methods. UAS technology will allow us to do more with less and in the process enhance our ability to provide unbiased scientific information to better enable decision makers to make informed decisions.

Q. What other types of research projects is USGS currently using unmanned systems for?

A. UAS technology is being made available to monitor environmental conditions, analyze the impacts of climate change, respond to natural hazards, understand landscape change rates and consequences, conduct wildlife inventories and support related land management missions. The wildlife biologists were the first implementers of the technology (monitoring and inventorying wildlife), followed by geologists (detecting landslides, mapping fault zones), hydrologists (monitoring shoreline erosion and stream temperature gradients) and ecologists (habitat mapping). The public safety components of the department are very interested in using UAS to support their missions including search and rescue, monitoring pipelines and wildland fire fighting.

Q. What are the benefits of using unmanned systems for USGS research?

A. Using UAS provides scientists a way to look longer, closer and more frequently at some of the most remote areas of the Earth — places that were previously too dangerous or too expensive to monitor in detail. The flexibility of operations and relative low cost of small unmanned aircraft systems enhances our ability to track long-term landscape change. In addition, we can quickly assess landscape-altering events, such as wildfires or volcanoes, in areas with challenging logistics. In many cases, UAS technology is simply the only cost-effective way to gather Earth observation data for a wide variety of applications: managing federal lands, investigating climate change, mapping and charting, conducting environmental risk assessments, responding to and recovering from natural and human-induced disasters.

Q. Why is it beneficial to use UAS as opposed to a helicopter or small plane?

A. Manned aircraft flights may not always be feasible because of concerns with long flight durations, requirement for low-altitude flying, hazardous weather conditions and associated operations cost. Satellite-based observations can be hindered by coarse image resolution, atmospheric conditions, limited sensor capabilities and repeat orbiting cycles of days or weeks. The use of UAS technology allows flexibility in delivering timely data. Furthermore, data collection by UAS can be specifically tailored to the required resolution and radiometric parameters of individual investigations. Our goal is to recognize a 10-to-1 cost savings by using a SUAS over traditional manned aircraft.

Q. What kinds of UAS is USGS using in its research?

A. USGS is currently using the AeroVironment Raven and Honeywell T-Hawk. The Raven is a 4.4-pound aircraft and the T-Hawk is a 20-pound hovercraft. We are operating SUAS because of acquisition and operations cost considerations. The smaller systems flying under controlled conditions are likely to be the first UAS systems approved for routine use in the National Airspace System. We project that SUAS will eventually be considered a piece of field equipment, much like GPS devices are today. However, the SUAS are designed to support short-duration missions. We anticipate contracting for data services with commercial UAS vendors in the near future for large acquisition requirements (i.e., state or national aerial photography or lidar surveys).

Q. For what type of projects do you see the USGS using UAS in the future?

A. UAS capabilities have demonstrated the ability to effectively fill the current observation gaps that are critical to gaining a better understanding of the complexities and scientific knowledge related to climate change research, water resources forecasting, ecosystem monitoring, and management and natural hazards. These information gaps in our observations frequently exist over the remote, scarcely populated and often volatile lands managed by the Department of the Interior (North Slope of Alaska; Volcanic Islands; Everglades; the vast, desolate areas found in the intermountain West) and other remote reaches of the Earth. The use of UAS technology allows flexibility in delivering timely data, for longer durations (persistent staring — such as shared real-time video feeds), tailored to the required resolution and radiometric parameters. UAS technology expands our ability to obtain remotely sensed data to inventory and monitor dynamic landscape altering events and conduct impact analysis over previously logistically challenging areas. We fully expect that by 2020 UAS will emerge as the primary platform for all DOI intelligence, surveillance and reconnaissance applications.

The USGS studied the use of Raven UAS to monitor fence lines around Haleakala National Park, Hawaii.